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Effect of Varied Levels of Dietary Protein on the Breeding Performance of Common Carp *Cyprinus carpio*

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Abstract

Breeding performance of common carp, *C. carpio* was assessed through a feeding trial using diets containing different levels of protein (25 to 41%). A control diet (diet A) was formulated using 1:1 mixture of rice bran (RB) and groundnut oil cake (GC) with 25% protein, while the test diets with 30% protein (diet B), 35% protein (diet C) and 40% protein (diet D) were developed using a combination of rice bran, groundnut cake and fish meal. All the diets were fortified with a vitamin supplement Vimeral at the rate of 0.01%. The ponds were manured with cowdung at regular intervals over the rearing period to ensure natural production of plankton. The best spawning response (weight loss 21.88% in female and 16.56% in male) with fecundity of 1,15,225 kg^{-1} was observed in fish fed with diet C. The weight of fertilized egg (2.07 mg), rate of fertilization (78.97%), hatching (78.97%) and hatchling weight (1.90mg) in this treatment were also the best. This study indicates that a protein level of 35% is necessary for common carp brooders through supplemental feed in addition to the natural food produced through fertilization.

Introduction

Fish seed production efficiency of many fish seed farms throughout India is poor due to poor broodstock management practices. Nutrition is known to have a profound effect on the reproductive performance of fish (Gunasekera et al. 1996a, 1996b; Mokoginata et al. 1998). Although precise information on the nutritional requirements for gonadal maturation in carps is lacking, there has been a general consensus that the nutritional requirements of broodstock during gonadal development varies from those of young fish. It has been observed in *Leptobarbus hoevenii*, guppy (*Poecilia reticulata*) and dwarf gourami (*Colisa lalia*) that increased protein in the diets results in greater ovary size and weight (Dahlgren 1980; Pathmasothy 1985 and Shim et al. 1989). Common carp is one of the most popular species in the Indian subcontinent and seed farms are confronted with poor spawning response and poor quality spawn. Hence, the present study was carried out to assess the effect of different levels of dietary protein on reproductive performance and identify the best protein level suited under tropical climate.

Materials and Methods

Advanced fingerlings of common carp (ave. wt. 18.5 g) were stocked in 4 earthen ponds of 600 m^2 each at the rate of 3,333·ha^{-1}. The ponds were fertilized with cowdung at 6000 kg·ha^{-1} about 15 days prior to stocking. One month after stocking, the ponds were refertilized with cowdung at 2,000 kg·ha^{-1} and thereafter fertilization was done at 1,000 kg·ha^{-1} at monthly intervals. The ingredients used, their proportion and proximate composition of the experimental diets are given in table 1. Powdered groundnut cake and other ingredients were mixed with water to form the dough. The dough was cooked in a pressure cooker for 30 min. Vimeral, a commercial vitamin supplement was added to the dough after cooling. The dough was placed in trays suspended in the ponds. Fishes were fed with different diets at 5% of their body weight and feeding level was reduced to 2.5% and 2% on the 30^{th} and 98^{th} days, respectively. Sampling for fish growth and water quality parameters (APHA 1985) was done at fortnightly intervals. Water was analyzed for dissolved oxygen, free carbon dioxide, total alkalinity, pH and temperature. The experiment was conducted for a period of 198 days.

On every breeding trial, four ready to spawn females and 5 to 6 males were kept in hapas. Four breeding trials were conducted for each treatment. The percentage weight loss was calculated based on the average weights of both females and males before and after breeding. The average number of eggs per gram of ovary was enumerated in triplicates from common carp of the same size range and the average taken formed the basis for calculating the number of eggs spawned per unit weight loss of female. Fecundity was calculated based on the number of eggs obtained per kg body weight of fish. Average diameter of the egg was calculated by measuring 100 eggs at random irrespective of their fertility, from each treatment. Fertilization rate was estimated by examining 100 eggs collected from each treatment. Hatching rate was calculated based on the number of eggs

Table 1. Proportion of ingredients and proximate composition (±S.D.) of experimental diets (dry weight basis).

	Diet			
	A	B	C	D
Ingredients (%)				
Rice bran	50	45	38	31
Groundnut cake	50	45	38	31
Fishmeal	-	10	24	38
Vimeral	0.01	0.01	0.01	0.01
Proximate composition (%)				
Dry matter	92.28±1.06	92.10±1.23	91.86±0.74	91.60±0.86
Crude protein	24.74±0.37	29.41±0.47	34.94±1.04	41.48±1.25
Lipid	4.75±0.34	4.46±0.17	4.05±0.10	3.64±0.03
Ash	13.05±0.16	13.10±0.32	13.19±0.09	13.28±0.18
Crude fibre	15.51±0.52	13.96±0.32	11.79±0.47	9.62±0.09
NFE	34.23	31.17	27.89	23.58
Gross energy (kJ·g^{-1})	12.69	13.05	13.50	13.99

hatched out by keeping 100 fertilized eggs from each treatment separately in petriplates. Egg weight and hatchling weights were determined by weighing 100 fertilized eggs and hatchlings from each treatment in an electronic balance. The average length of hatchling was calculated by measuring 100 hatchlings at random. The data were analyzed by one-way ($y_{ij} = \mu + t_i + e_{ij}$) ANOVA (Snedecor and Cochran 1968) followed by Duncan's (1955) multiple range test.

Results

The water temperature of ponds ranged from 26.0 to 32.0°C over the experimental period. The dissolved oxygen was above 5.6 ppm (5.60 to 10.0 ppm) while the carbon dioxide level always remained low (0 to 6.0 ppm). The pH of water was alkaline throughout the experimental period (7.2 to 8.4). The alkalinity and plankton dry weight recorded ranged from 38.0 to 112.0 ppm and 10.0 to 80.0 mg·100 l^{-1} respectively. Generally, water quality parameters did not vary largely between the treatments and were found to be optimum for the survival and growth of common carp (Jhingran 1991).

The average weight of breeders, weight loss after breeding, egg diameter and weight, fecundity, percentage fertilization, hatching rate and length and weight of hatchlings in different treatments are presented in table 2. In all the treatments, the female spawners selected recorded higher average weight compared to males. However, as more males than females were used for each breeding trial, the total weight of males always exceeded that of the females. In females, breeding weight loss progressively increased in treatments A, B and C with 25, 30 and 35% protein respectively and the difference was significant ($P < 0.05$). Treatment D recorded the lowest weight loss but was not significantly different from treatment A. However, in males treatment B and C recorded significantly low and higher values respectively while A and D were similar without any significant difference between them. Treatment C with diet containing 35% protein recorded significantly ($P< 0.05$) higher weight loss after breeding in both males and females. The fecundity and weight of eggs were also significantly higher compared to other treatments. Treatment C also recorded the highest fertilization rate, egg diameter and weight of hatchlings. Among the treatments, highest average weights of female and male breeders used were in treatment C. However, fecundity and weight of brood did not show any definite relationship.

Discussion

Female dwarf gourami and Nile tilapia fed on 35% protein diets recorded highest ovary weight and gonadosomatic index (Shim et al. 1989; Santiago et al. 1985). Pathmasothy (1985) recorded larger ovaries and higher gonadosomatic index values of *L. hoevenii* fed diets containing 32

Table 2. Effect of feeding different levels of protein on the breeding performance of common carp.

Diet	Range ave.wt. female (g) (n=16)	Range ave.wt. male (g) (n=24)	Range and ave. wt. loss (%)		Fertln. (%) (n=400)	Ave. fec. per kg wt. (n=12)	Ave. egg diam. (mm) (n=400)	Ave. egg wt. (mg) (n=400)	Hatching % (n=400)	Hatchling	
			Female (n=16)	Male (n=24)						Ave. length (mm) (n=400)	Ave. wt. (mg) (n=400)
A	325-506	256-414	8.64-20.0	5.06-23.33	75.78^{ab}	$87,165^{b}$	1.42^{ab}	1.99^{b}	70.22^{b}	5.14^{a}	1.26^{a}
	(422.23)	(351.95)	(14.58^{a})	(14.84^{b})	(1.31)	(3014)	(0.19)	(0.03)	(0.68)	(0.04)	(0.03)
B	325-476	248-435	9.00-27.18	5.96-25.54	78.41^{bc}	$88,477^{b}$	1.44^{ab}	1.91^{a}	68.00^{a}	5.22^{b}	1.85^{c}
	(392.38)	(317.86)	(17.46^{b})	(13.31^{a})	(2.03)	(2773)	(0.11)	(0.03)	(0.91)	(0.03)	(0.11)
C	450-569	367-505	15.38-26.02	5.94-26.17	78.97^{c}	$115,255^{c}$	1.48^{b}	2.07^{c}	78.97^{c}	5.15^{a}	1.90^{c}
	(487.40)	(427.12)	(21.88^{c})	(16.56^{c})	(0.88)	(7329)	(0.06)	(0.05)	(1.20)	(0.04)	(0.08)
D	456-517	306-444	10.75-18.10	9.03-19.28	74.28^{a}	$77,176^{a}$	1.38^{a}	1.99^{b}	87.02^{d}	5.19^{ab}	1.33^{b}
	(482.92)	(398.16)	(14.43^{a})	(14.52^{b})	(1.33)	(2431)	(0.05)	(0.04)	(2.21)	(0.06)	(0.03)

Figures in the same column with same superscript are not significantly different ($P > 0.05$).
Numbers in parentheses for fertilization, fecundity, egg diameter and weight, hatching and hatchling's length and weight indicate standard deviation.

and 40% protein than diet with 24% protein. In the present study, the spawning weight loss and the fecundity recorded in common carp was the maximum in 35% protein diet. The higher fecundity, egg size and viability may be a result of larger female size in the 35% diet group. Many factors influence the potential fecundity of an individual fish namely, age, size, reproductive history, physical condition and in particular its nutritional status. De Silva and Radampola (1990) stated that tilapia receiving a lower protein (20%) diet had a higher relative fecundity and spawned a greater number of times compared to those receiving diets with 25 and 30% protein. This was in agreement with the results obtained by Mironova (1978) who showed that reduced food of a uniform quality induced reproduction in female *Tilapia mossambica*. However, Pathmasothy (1985) recorded an increase in fecundity with increasing dietary protein from 24 to 32% protein in *L. hoevenii*. A further increase of the latter to 40% resulted in decreased fecundity, which however was not significantly different from that of 32%. On the other hand, Dahlgren (1980) and Gunasekera et al. (1996a) reported that relative fecundity remained almost unaffected by a reduced amount of protein. A low protein diet produced eggs lower in hatchability, and a dietary protein level of 45% was optimal for the fecundity, number of viable eggs and hatchability in red sea bream (Watanabe et al. 1984) and dwarf gourami (Shim et al. 1989).

In the present study, female common carp fed 35% protein diet had the highest egg diameter, fertilization rate and length and weight of hatchlings. Dahlgren (1980) and Gunasekera et al. (1996a) noted that ovum size (diameter), an important criterion in the assessment of the reproductive performance remained the same between fish fed diets with different protein levels. In the present study except in treatment D where the egg diameter was significantly lower than treatment C, there was no significant difference in the egg diameter recorded among all other treatments. The hatching percentage, on the other hand, showed a direct relationship with dietary protein level. This is in agreement with the results recorded by Gunasekera et al. (1996b) who showed that among the three diets with 10, 20 and 30% crude protein, the diets with the highest level of protein resulted in significantly higher hatchability in Nile tilapia. It is interesting to note that the egg diameter and weight of hatchling recorded in the present study were lower in fish fed 41% protein diet indicating the unsuitability of 41% protein diet for common carp brooders and the adequacy of 35% protein diet. However, Jhingran and Pullin (1985) have recommended a slightly lower protein content of about 30% for common carp brood supplemental feed.

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